SENSORS & ACTUATORS (SESSION-5)

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TERMINOLOGIES USED IN CONTROL

- Plant or process: System to be controlled .
- Inputs: Excitations (known, unknown) to the system .
- Outputs: Responses of the system .
- Sensors: Devices that measure system variables (excitations, responses, etc.) .
- Actuators: Devices that drive various parts of the system .
- Controller: Device that generates control signal .
- Control law: Relation or scheme according to which control signal is generated .
- Control system: At least the plant and the controller (may include sensors, signal conditioning, and other components as well) .
- Feedback control: Control signal is determined according to plant response .
- Open-loop control: Plant response is not used to determine the control action .
- Feed-forward control: Control signal is determined according to plant excitation

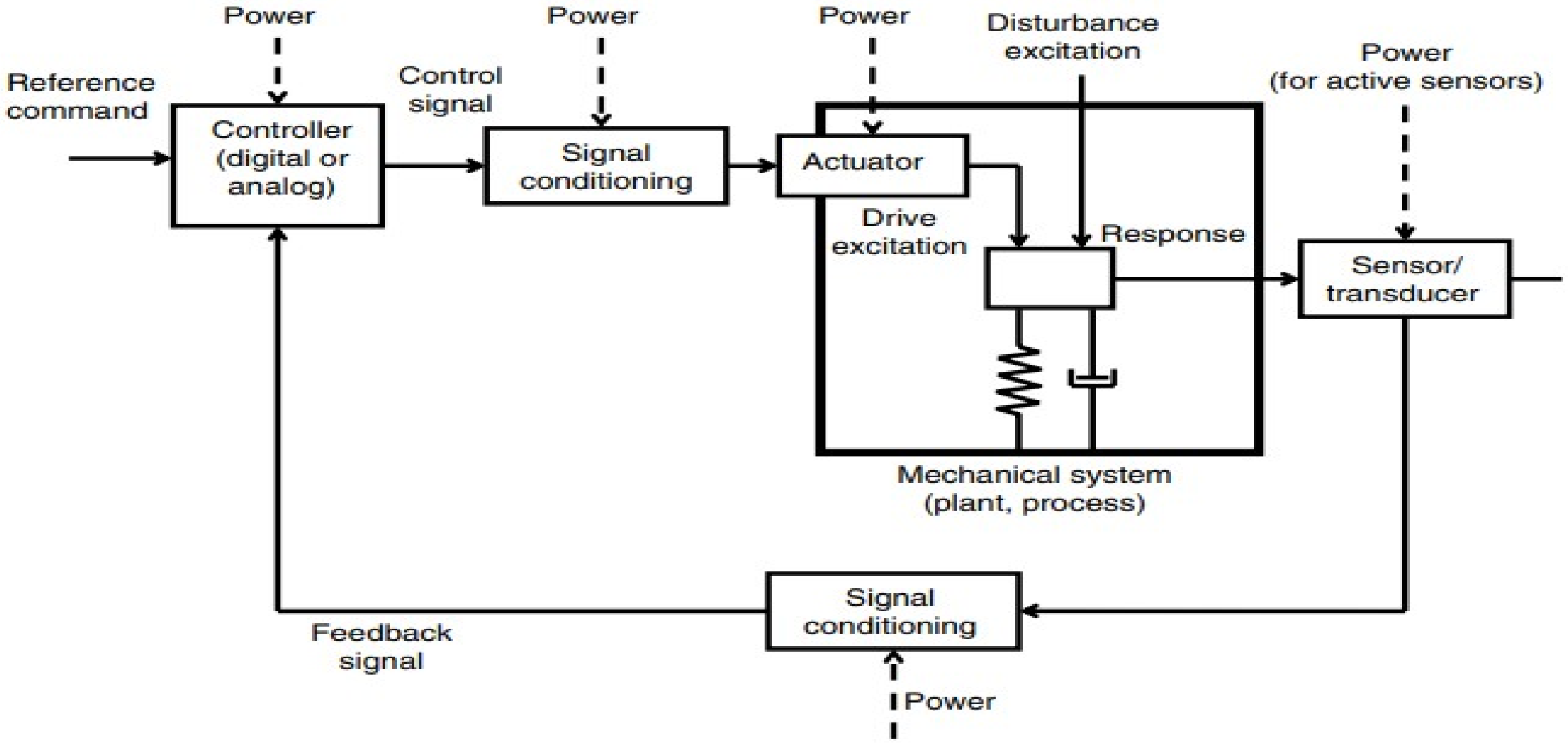


FIGURE 1.2
Schematic diagram of a feedback control system.

Source: Sensors & Actuators: Control System Instrumentation, Clarence W. de Silva, CRC Press, 2007

CLASS ACTIVITY 5.2

- Draw an open loop control system

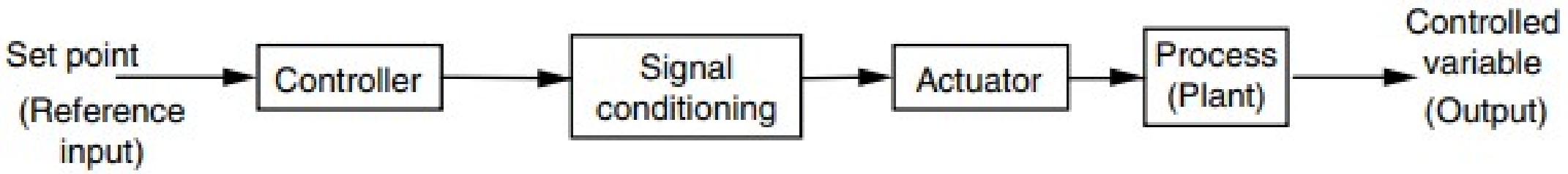


FIGURE 1.4
An open-loop control system.

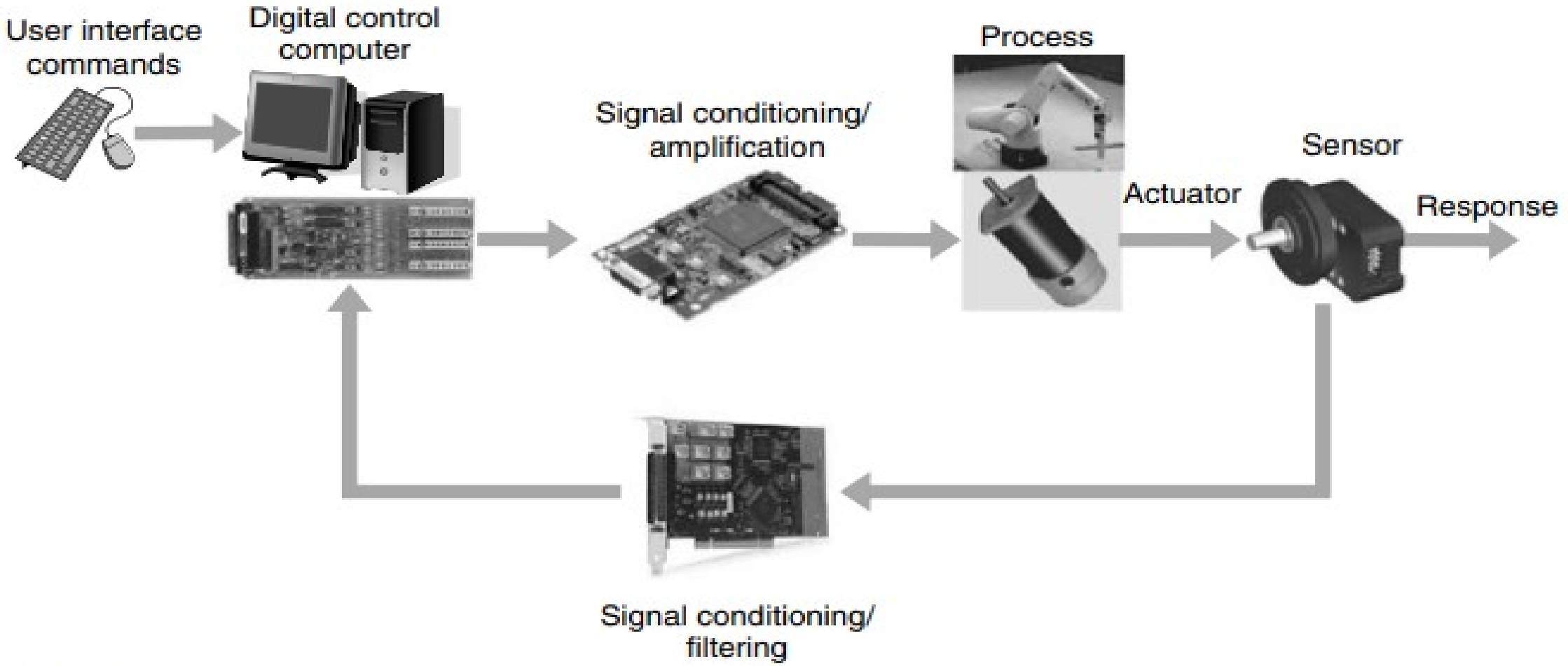


FIGURE 1.3
An instrumented feedback control system.

Source: Sensors & Actuators: Control System Instrumentation, Clarence W. de Silva, CRC Press, 2007

APPLICATION OF FEEDBACK CONTROL

- **Smart grids**
- **Power systems**
- **Aerospace**
- **Robotics**
- **Intelligent transportation systems**

CLASS ACTIVITY 5.3: RECOGNIZE THE FUNCTION(S)

$$c = k_p\left(e + \tau_d\dot{e} + \frac{1}{\tau_i}\int e\,dt\right)$$

$$\frac{c}{e} = k_p\left(1 + \tau_d s + \frac{1}{\tau_i s}\right)$$

TABLE 1.2

Comparison of Some Common Control Actions

Control Action	Control Law	Advantages	Disadvantages
On/off	$\frac{c_{max}}{2}[\text{sgn}(e)+1]$	Simple Inexpensive	Continuous chatter Mechanical problems Poor accuracy
Proportional	$k_p e$	Simple Fast response	Offset error (Steady-state error) Poor stability
Reset (Integral)	$\frac{1}{\tau_i}\int e\,dt$	Eliminates offset Filters out noise	Low bandwidth (Slow response) Reset windup Instability problems
Rate (Derivative)	$\tau_d\frac{de}{dt}$	High bandwidth (Fast response) Improves stability	Insensitive to DC error Allows high-frequency noise Amplifies noise Difficult analog implementation

CLASS ACTIVITY 5.4:
GIVE EXAMPLE OF
FEEDFORWARD SIGNAL

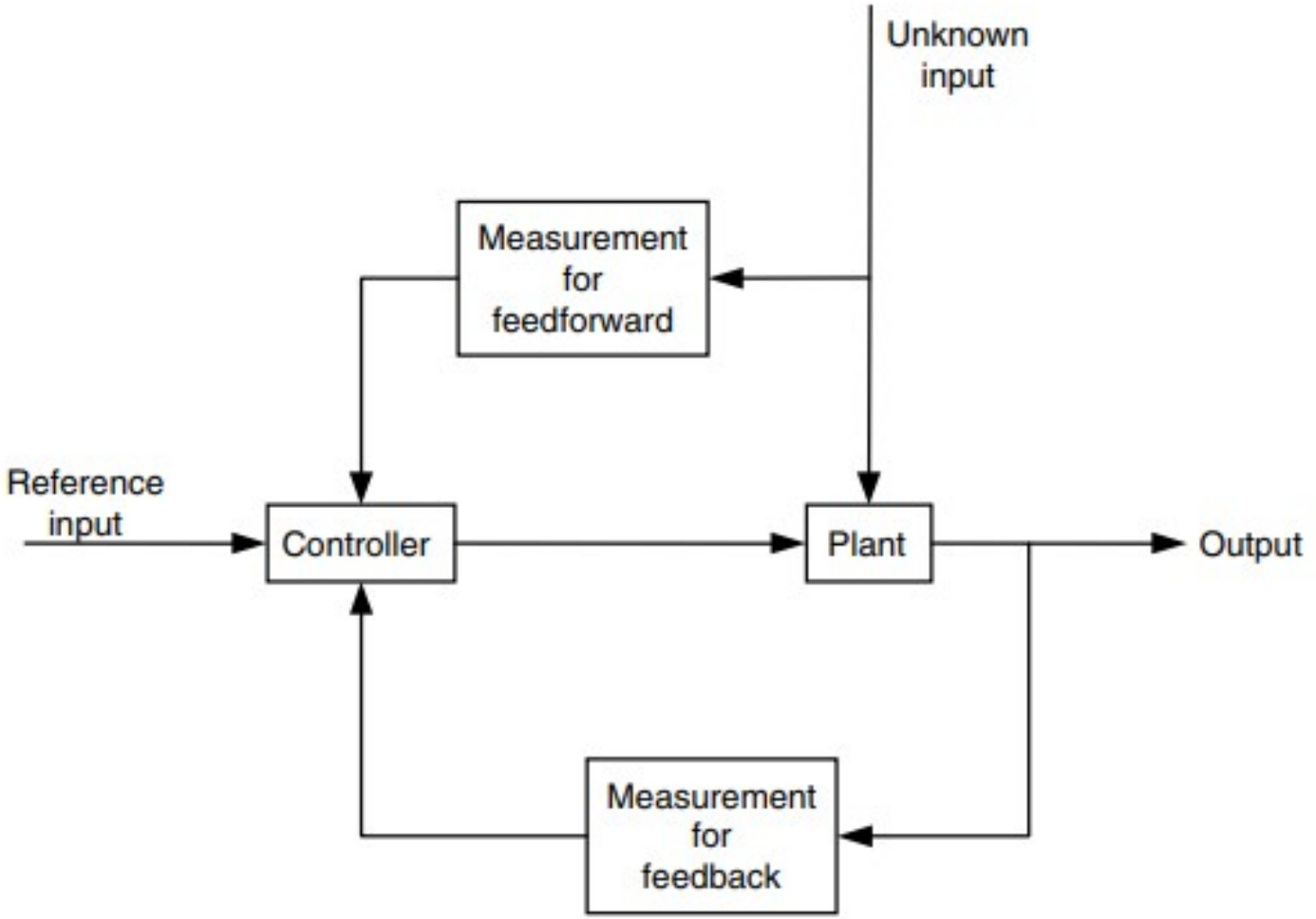
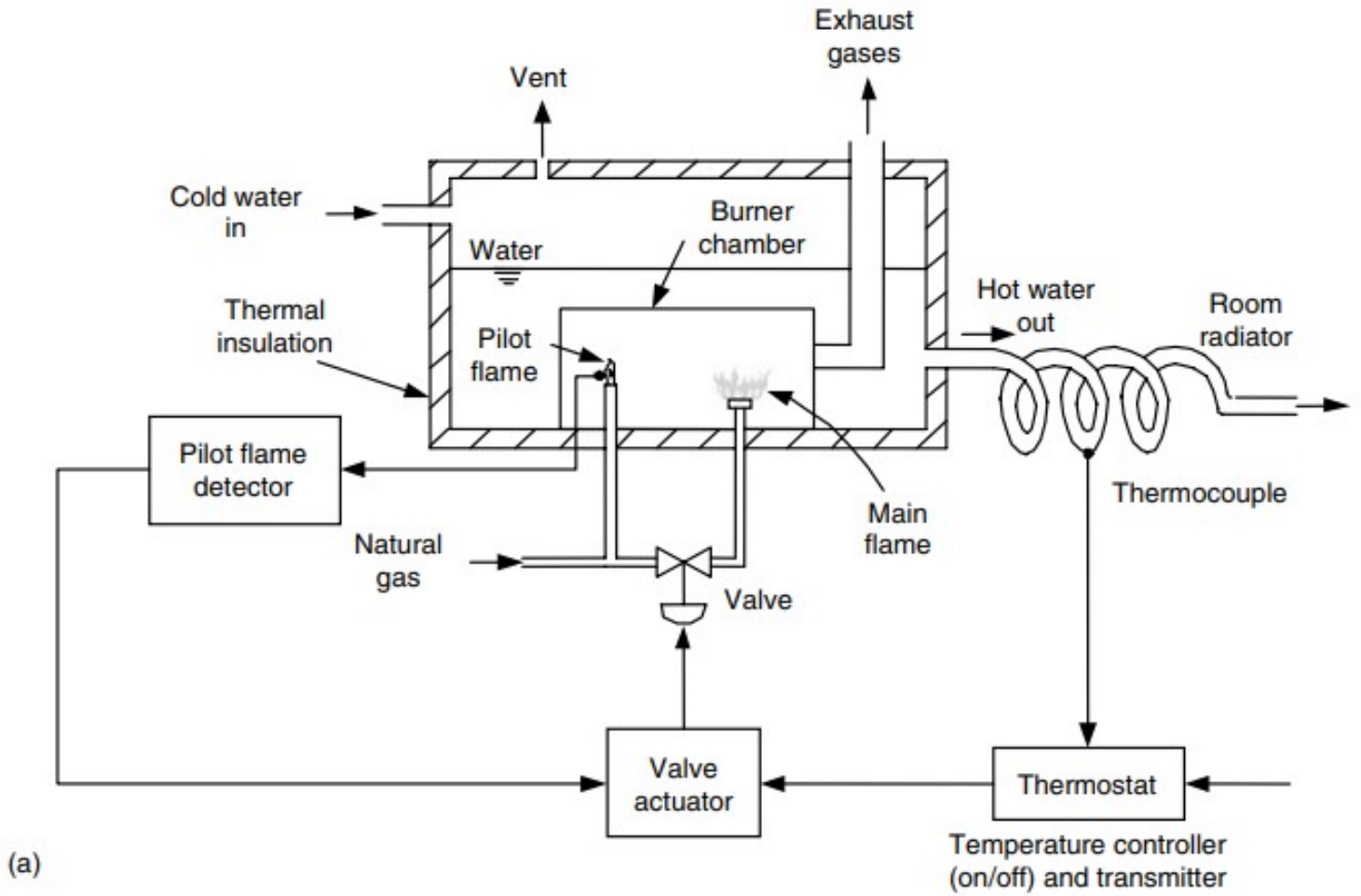


FIGURE 1.5
A system with feedback and feedforward control.

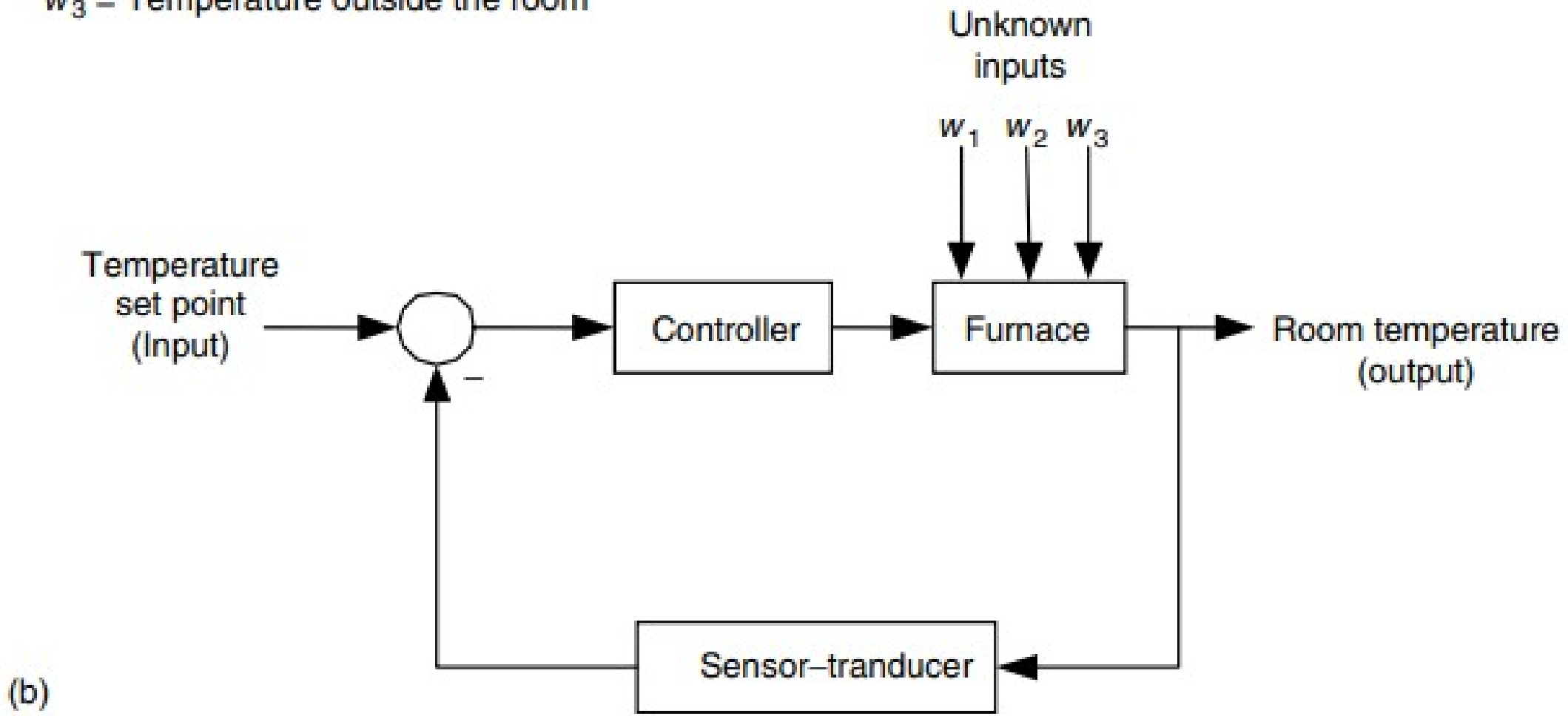
CLASS ACTIVITY 5.5: DRAW THE BLOCK DIAGRAM FOR CONTROL SYSTEM



w_1 = Water flow rate

w_2 = Temperature of cold water into furnace

w_3 = Temperature outside the room



(b)

ACTIVITY 5.6: DRAW SCHEMATIC REPRESENTATION OF A PLC

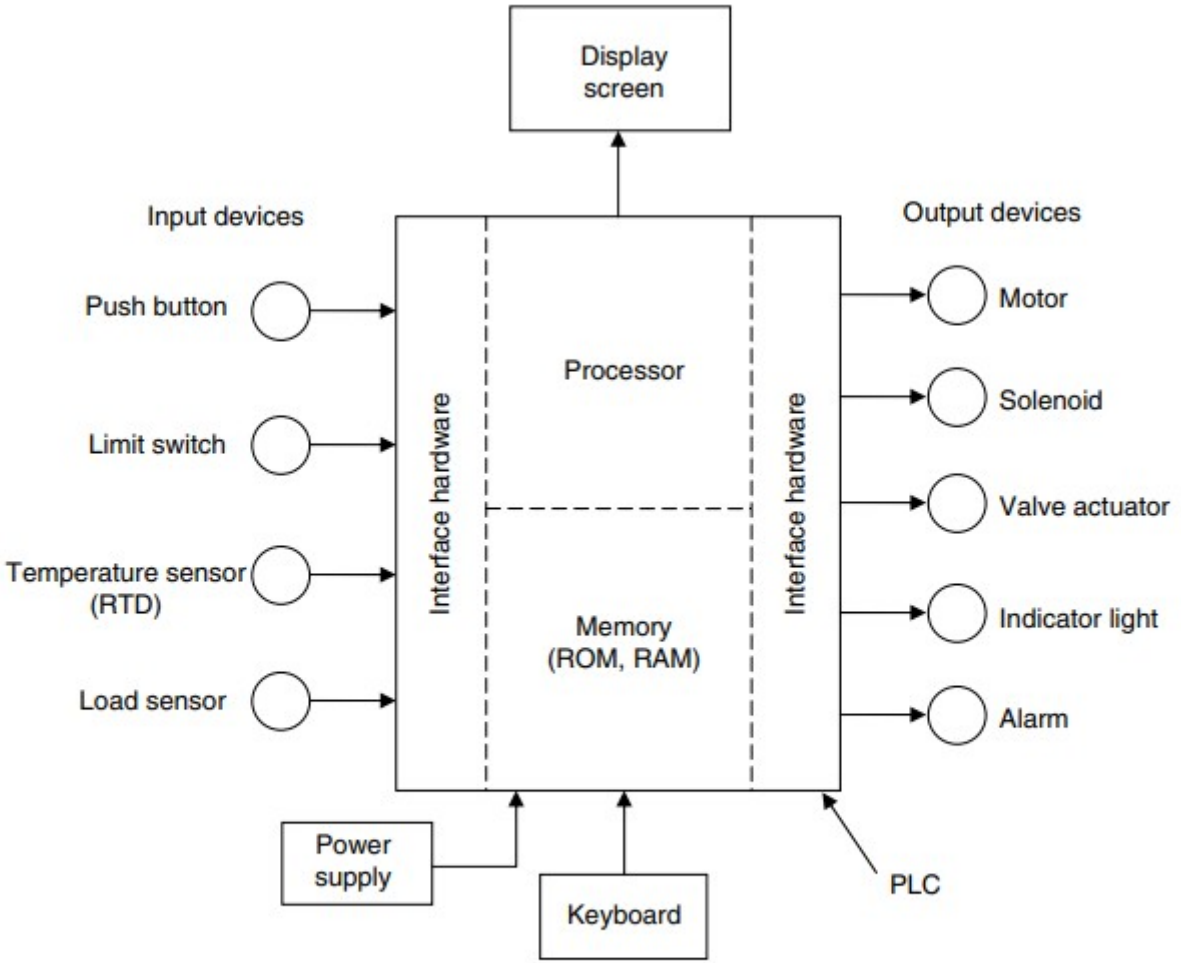
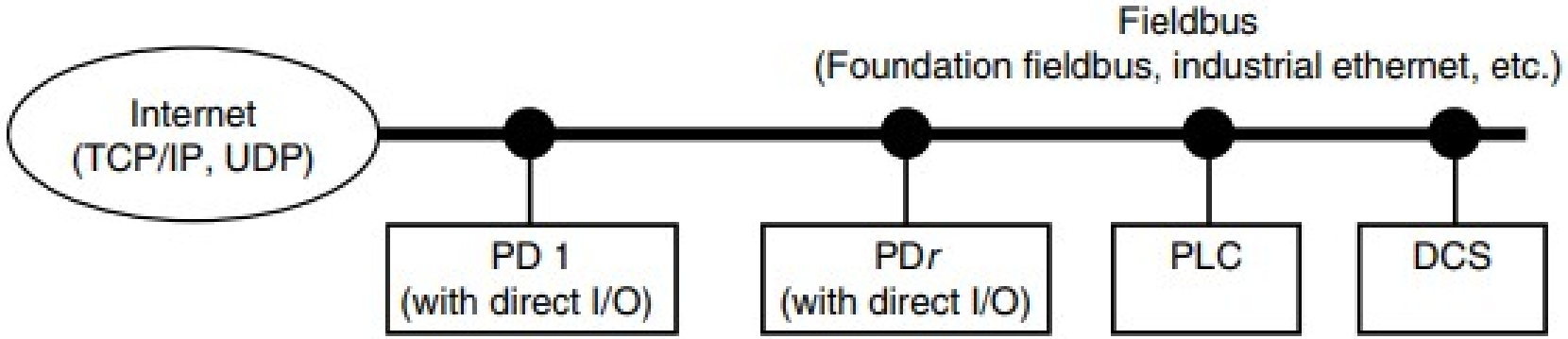


FIGURE 1.7
Schematic representation of a PLC.

DISCUSSION ON NETWORKED INDUSTRIAL PLANT



PD = Process device
PLC = Programmable logic controller
DCS = Distributed control system (Supervisory controller)

FIGURE 1.8
A networked industrial plant.

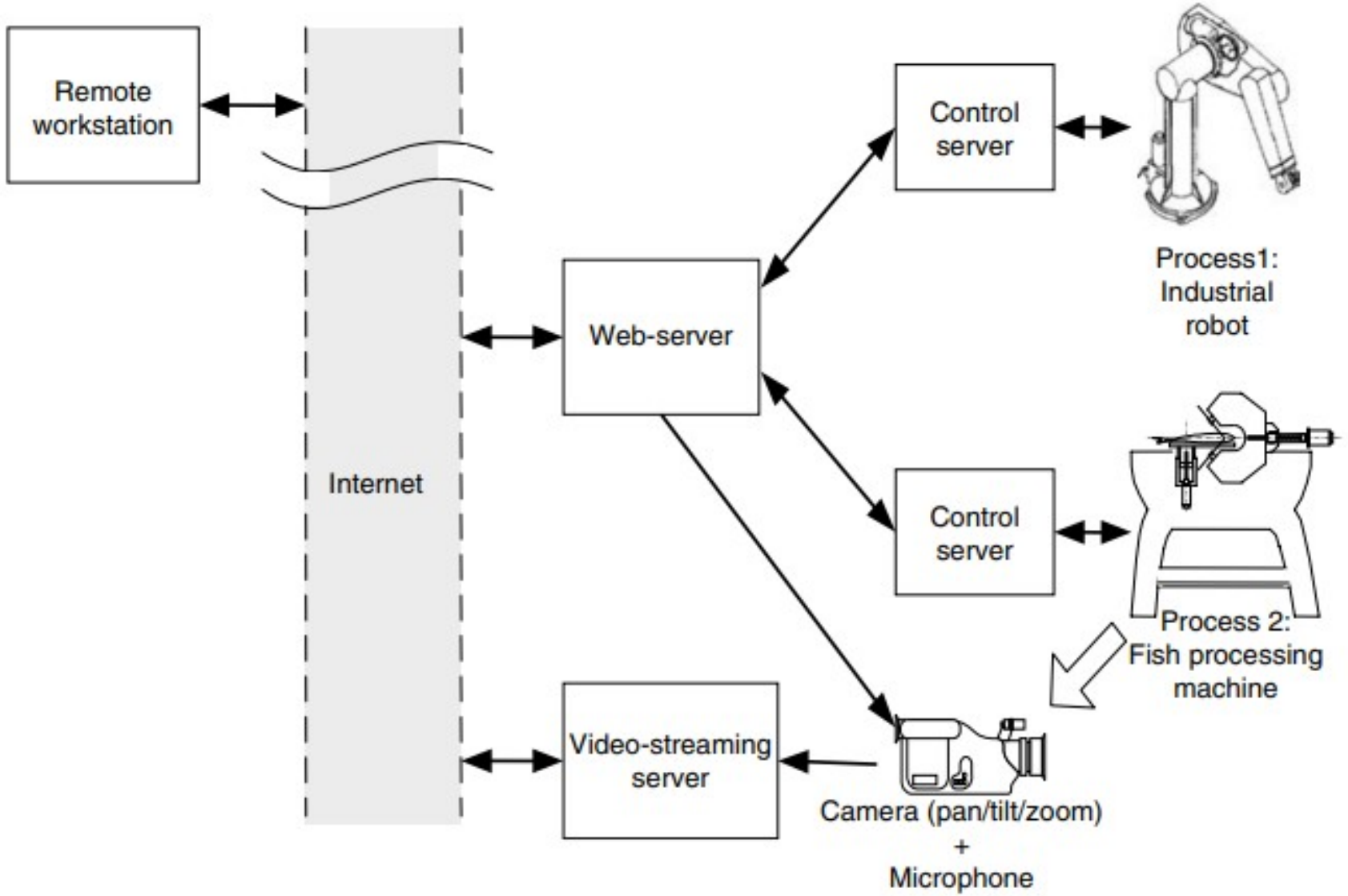


FIGURE 1.10
Network hardware architecture.

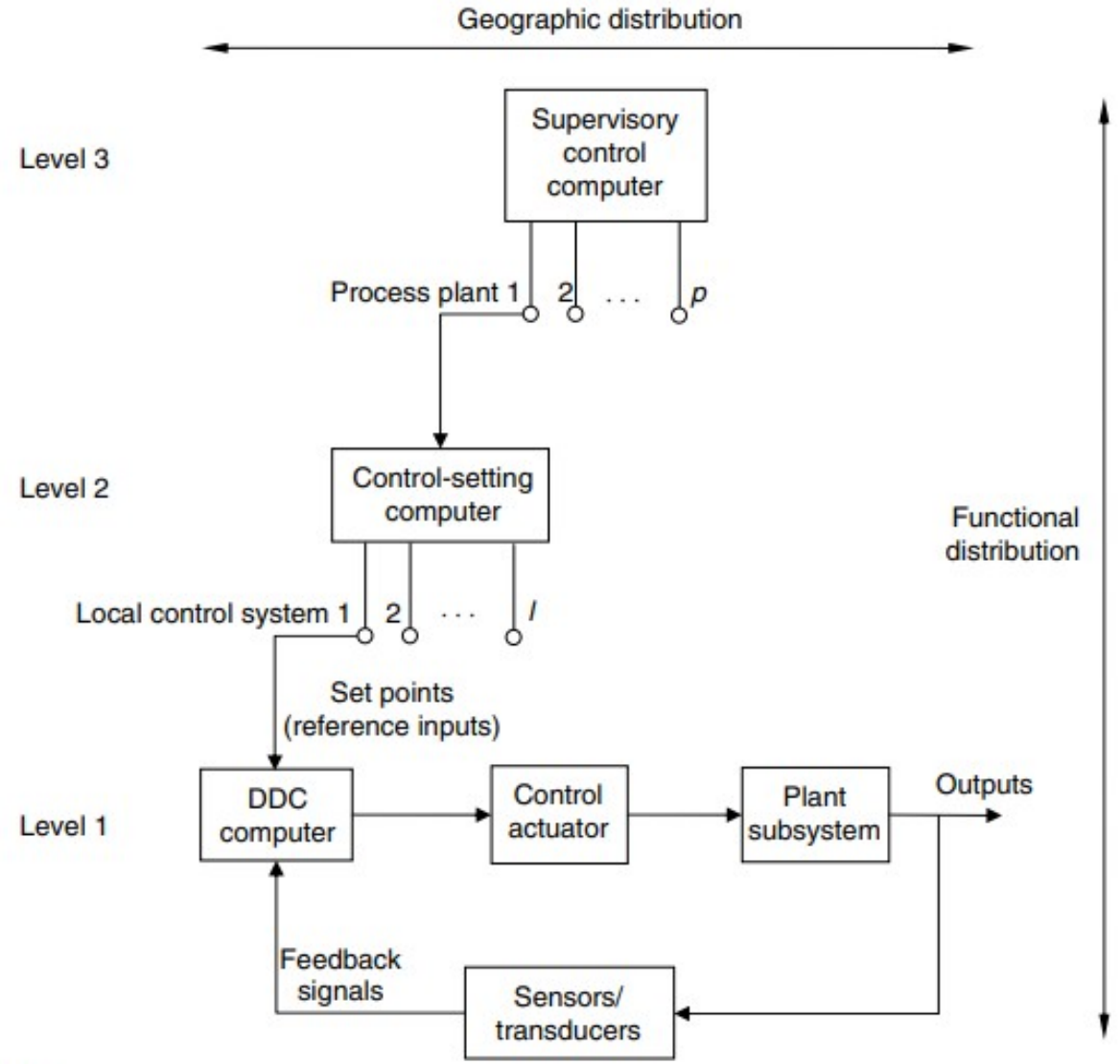


FIGURE 1.11
A three-layer hierarchical control system.